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AUTHOR Fischl, M. A.; And Others
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ABSTRACT

The purpose of this research was to develop composites of subtests of the Armed Services Vocational Aptitude Battery (ASVAB) such that each composite score would be reliable and the various composite scores would be factorially independent of each other. Factor analysis was used to cluster the tests into composites based on the underlying dimensions of ability in the ASVAB. A principal factor solution was rotated to simple oblique structure to achieve the following five ability factors: (1) verbal; (2) analytic/quantitative; (3) clerical; (4) mechanical, including space perception; and (5) trade technical. These factors had high reliability and relatively low intercorrelations. One last score composite, called academic ability, was added to the factorially based composites as an indicator of the ability to succeed at further school or formal training. (Author/CTM)

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Technical Paper 360

DEVELOPMENT OF FACTORIALLY BASED ASVAB HIGH SCHOOL COMPOSITES

M. A. Fischl, Robert M. Ross, and
James R. McBride

PERSONNEL AND MANPOWER TECHNICAL AREA

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The Armed Services Vocational Aptitude Battery (ASVAB) is used for selection and classification purposes by the military services and for vocational guidance in high schools. The purpose of this research was to improve score composites for the specific use of vocational guidance in the high schools.

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Factor analysis was used to cluster the tests into composites based on the underlying dimensions of ability in the ASVAB. A principal factor solution was rotated to simple oblique structure to achieve the following five ability factors: verbal, analytic/quantitative, clerical, mechanical, and trade technical. These factors have high reliability and relatively low intercorrelations. One last score test composite, called academic ability, was added to the factorially based composites as an indicator of the ability to succeed at further school or formal training.

The report is written primarily for scientific investigators in psychometrics.

Technical Paper 360

DEVELOPMENT OF FACTORIALLY BASED ASVAB HIGH SCHOOL COMPOSITES

M. A. Fischl, Robert M. Ross, and
James R. McBride

Submitted by:
Ralph R. Canter, Chief
PERSONNEL AND MANPOWER TECHNICAL AREA

Approved By:

E. Ralph Dusek
PERSONNEL AND TRAINING
RESEARCH LABORATORY

Joseph Zeidner
TECHNICAL DIRECTOR

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has been responsible for the Army's research on the Armed Services Vocational Aptitude Battery (ASVAB), which is utilized for selection and classification of enlisted personnel. A parallel form of this battery is administered to high school students who wish to be tested to aid in general vocational planning.

This report describes the development of revised high school test composite measures that are designed to be relevant to general vocational counseling dimensions rather than strictly functions of the military job domain. The research was accomplished by personnel of the ARI Personnel and Manpower Technical Area, one of whom, Dr. McBride, is now with the Naval Personnel Research and Development Center at San Diego. Work was done under Army Project 2Q163731A768, Manpower Accession and Retention Systems, in response to requirements from the Deputy Chief of Staff for Personnel.

JOSEPH ZEIDNER
Technical Director

DEVELOPMENT OF FACTORIALLY BASED ASVAB HIGH SCHOOL COMPOSITES

BRIEF

Requirement:

To develop revised Armed Services Vocational Aptitude Battery (ASVAB) subtest composites for the specific purpose of high school vocational guidance.

Procedure:

The ASVAB (Form 5) administered to high school students consists of 12 subtests. To develop subtest composites that would be most suitable for high school counseling, dimensions of ability underlying the test battery were defined through the use of factor analysis. This methodology is substantially different from previous sets of composites developed to relate to specific military job groupings. The data analyzed were from a sample of more than 2,000 10th, 11th, and 12th graders generally representative of the national population of high school students.

Findings:

Five non-overlapping clusters of tests were found that best defined each of five factors. The factors were (1) Verbal Ability--knowledge of words and reading comprehension; (2) Analytic/Quantitative Ability--general reasoning and mathematical knowledge; (3) Clerical Ability--speed and accuracy in using letters and numbers; (4) Mechanical Ability--understanding mechanical principles and visualizing objects in three-dimensional space; and (5) Trade Technical Knowledge--relevant to automotive information and shop practices. A sixth composite, not drawn from the factor analysis, called Academic Ability, helps the counselor understand the level of education or training most appropriate to the student.

Utilization of Findings:

The new composites became operational in the high school testing program in school year 1977-78.

DEVELOPMENT OF FACTORIALLY BASED ASVAB HIGH SCHOOL COMPOSITES

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DEVELOPMENT OF FACTORIALLY BASED ASVAB HIGH SCHOOL COMPOSITES

INTRODUCTION

The Armed Services Vocational Aptitude Battery (ASVAB) is a set of short, relatively homogeneous, ability tests designed for two broad applications: (1) selection and classification of applicants for military enlistment, and (2) vocational guidance in high schools. Three forms of ASVAB are currently in operational use; ASVAB-5 is used in a testing program offered to high schools nationwide, and ASVAB-6 and ASVAB-7 are used for military entrance examining purposes. This report is concerned with ASVAB-5, the high school testing battery, the scores of which are provided to school guidance specialists for individual counseling purposes. The report will present in brief detail the development of an improved set of composites to be used for counseling in the high school program.

ASVAB-5 consists of 12 subtests listed in Table 1. The scores reported to counselors and students are composites formed from weighted sums of the subtest scores. In the 1976-77 school year, six composite scores were used: Electronic/Electrical (EL), Communications (CO), General Technical (GT), Motor Mechanical (MM), General Mechanical (GM), and Clerical/Administrative (CL). The definitions of these composites in terms of their constituent ASVAB subtests are given in Table 2.

Table 1

The 12 Ability Subtests of the Armed Services Vocational Aptitude Battery, Form 5 (ASVAB-5)

1. General Information (GI)
2. Numerical Operations (NO)
3. Attention to Detail (AD)
4. Word Knowledge (WK)
5. Mathematics Knowledge (MK)
6. Arithmetic Reasoning (AR)
7. Space Perception (SP)
8. Mechanical Comprehension (MC)
9. General Science (GS)
10. Shop Information (SI)
11. Automotive Information (AI)
12. Electronics Information (EI)

Table 2

Names and Definitions of ASVAB-5 Composites Used in School Year 1976-77

Name	Symbol	Definition[a]
Electronic/Electrical	EL	AR + EI
Communications	CO	AR + MC + SP
General Mechanical	GM	AR + SP + SI
Motor Mechanical	MM	MK + MC + AI
General Technical	GT	AR + WK
Clerical/Administrative	CL	WK + AD + NO

[a]The respective composites are formed by summing the raw scores on the subtests defining them.

METHOD

The original ASVAB-5 composites had been defined judgmentally on the basis of the ability each subtest was known to measure (using empirical relationships in the research of the services for predicting success in military training and work). These compositing judgments, although made by experts, were necessarily subjective. One aim in defining a new set of composites was to stress objective analytic methods. Factor analysis of the intercorrelations among the 12 ASVAB subtests was used to determine common ability dimensions underlying the interrelationships among the subtests.

The data analyzed consisted of the matrix of ASVAB-5 subtest intercorrelations obtained by Fletcher and Ree,[1] and listed in Table 3. This correlation matrix was obtained in a sample of 2,052 volunteers approximately equally distributed among 10th-, 11th-, and 12th-grade males and females in what was described by Fletcher and Ree as "a geographically stratified selection of schools interested in vocational testing, in numbers approximately proportional to the national mixture of public versus private, and urban versus suburban versus rural schools" (p. 13).

[1]Fletcher, J. and Ree, M. J. Armed Services Vocational Aptitude Battery (ASVAB) Correlation Analysis, ASVAB Form 2 Versus ASVAB Form 5 (AFHRL-TR-76-70). Personnel Research Division, Air Force Human Resources Laboratory, Lackland Air Force Base, Tex., October 1976.

Table 3

Matrix of Intercorrelations of ASVAB-5 Subtests (N = 2,052)

	AR	EI	SP	AI	MC	SI	WK	AD	NO	MK	GS	GI
AR	(.6999)	.522	.508	.399	.539	.446	.623	.224	.434	.704	.530	.470
EI		(.6985)	.458	.616	.704	.661	.561	.147	.279	.487	.639	.527
SP			(.5218)	.339	.523	.383	.456	.202	.315	.525	.430	.337
AI				(.6975)	.617	.691	.371	.055	.151	.324	.555	.465
MC					(.7224)	.638	.514	.116	.224	.499	.625	.512
SI						(.6990)	.461	.107	.253	.402	.598	.502
WK							(.6693)	.184	.412	.638	.633	.517
AD								(.4654)	.455	.224	.118	.136
NO									(.5317)	.502	.270	.276
MK										(.7276)	.544	.430
GS											(.6598)	.438
GI												(.5281)

Note: Diagonal values are estimated communalities used in the factor analysis.

Source: Fletcher and Ree (1976).

The matrix was factor analyzed using a principal factor solution (with estimated communalities) followed by rotation to oblique simple structure using a direct oblimin solution with delta set at zero.[2]

RESULTS AND DISCUSSION

A five-factor oblimin solution was chosen; the resulting factor pattern weights for each subtest variable are presented in Table 4. Each row of the table contains the loadings of the five factors on the corresponding variable, i.e., the contributions of each factor to the variable. Table 4 shows that the first factor had high loadings on three ASVAB subtests; the remaining four factors each loaded high on a unique set of two ASVAB subtests. The sets of subtests for which each factor was most salient were all readily interpretable. For instance, Factor 1 was the predominant factor in subtest WK (Word Knowledge), GS (General Science), and GI (General Information); all three of these require comprehension of verbal material. Factor 2 was most important for subtests AD (Attention to Detail) and NO (Numerical Operations), both of which stress speed and accuracy in simple processing of letters and numbers. Factor 3 was most salient in subtests MK (Mathematics Knowledge) and AR (Arithmetic Reasoning), subtests which require the application of quantitative concepts and abstract reasoning. Factors 4 and 5 were just as readily interpretable in terms of the subtest variables to which they contributed most heavily--spatial relations and mechanical comprehension for the former, automotive repair and shop practices for the latter.

The set of ASVAB-5 subtests to which each factor contributed most heavily may be considered as a cluster. The five clusters were used to define new ASVAB-5 composites; these are described and interpreted in Table 5. There is no overlap in these five composites; i.e., no subtest appears in more than one composite. Every subtest except Electronics Information (EI) is represented in a composite; EI is obviously factorially complex, with heavy loadings being contributed by three factors--verbal, trade technical, and mechanical. Each composite is readily interpretable in terms of a basic and relatively specific ability. A sixth composite, not drawn from the factor analysis, was added to provide the counselor with an indication of general ability and academic promise. This composite, Academic Ability, consists of subtests WK and AR and has a long history of application in military settings and in commercial test batteries.

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[2] For details see Nie, N. H., Hull, C. H., et al., Statistical Package for the Social Sciences (Second Edition). New York: McGraw-Hill, 1975, p. 486.

Table 4

Factor Pattern Matrix Resulting From Factor Analysis of the Correlation Matrix, Using Direct Oblimin Rotation With Kaiser Normalization

Subtest variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
AR	.17856	.05936	.43495	.28395	.14350
EI	.39913	.04127	-.12180	.24093	.32767
SP	-.00629	.07499	.09922	.64568	.00602
AI	-.04735	-.02567	.02823	.03988	.84740
MC	.23562	-.03568	-.14117	.49843	.30191
SI	.11269	.05944	.01555	.01447	.72998
WK	.77457	.04467	.13393	.07434	-.14090
AD	-.03157	.71443	-.08951	.03585	-.02570
NO	.08062	.57876	.24056	-.03701	.06491
MK	.23515	.08232	.50428	.24859	.03543
GS	.60292	-.04704	-.01112	.12549	.16549
GI	.53319	.06401	.01134	-.07094	.22315

Table 5

Names, Definitions, and Interpretations of the Factor Analytically Derived ASVAB-5 Composites

Symbol	Name	Definition	Interpretation
V	Verbal Ability	WK + GI + GS	Measures knowledge of words, ability to understand written materials and to deal with verbal concepts. The composite is a combination of the scores on the Word Knowledge, General Information, and General Science tests.
AQ	Analytic, Quantitative Ability	AR + MK	Measures reasoning abilities as well as those relevant to understanding quantitative concepts. The composite is a combination of the scores on the Arithmetic Reasoning and Mathematics Knowledge tests.
CL	Clerical Ability	3AD + NO	Measures speed and accuracy in using letters and numbers. These are abilities relevant to clerical types of activities. The composite is a combination of the scores on the Attention to Detail and Numerical Operations tests weighted to equalize the contribution of each.
M	Mechanical Ability	SP + MC	Measures understanding of mechanical principles as well as the ability to visualize objects in three-dimensional space. The composite is a combination of the scores on the Space Perception and Mechanical Comprehension tests.

Table 5 (Continued)

Symbol	Name	Definition	Interpretation
TT	Trade Technical	AI + SI	Measures information relevant to automotive and various shop practices. The composite is a combination of the scores on the Automotive Information and Shop Information tests.
AA	Academic Ability	WK + AR	Measures abilities needed to do well in school and formal types of training. The composite is a combination of the scores on the Word Knowledge and Arithmetic Reasoning tests.

Table 6 contains the intercorrelations among the new ASVAB-5 composites, along with their internal consistency reliability coefficients. These reliabilities are based on the subtest internal consistency reliabilities obtained in the original ASVAB-5 standardization sample (N = 610) reported in Jensen, Massey, and Valentine.[3] These coefficients were then combined using a correlation of sums procedure to obtain the composite reliabilities. As Table 6 shows, the mean intercorrelation among the five specific ability composites is 0.51. The correlations of the five specific-ability composites with the general ability composite, AA, are shown separately; these five correlations average 0.67. The reliabilities of the six composites are all high; the average is .90, and the range is from .88 to .92.

CONCLUSIONS

As described above, a set of six new ASVAB-5 composites was developed. Five of the composites are measures of differential abilities derived from the results of factor analysis; the sixth composite was added to provide a general measure of academic ability. The five differential ability composites in the aggregate utilize all the ASVAB-5 subtests except Electronics Information, with no subtest appearing in more than one composite. The differential ability composites have desirably low to moderate intercorrelations, while each composite has high reliability. The composites are readily interpretable as measures of differentiated abilities. This, combined with their high reliability, should make them useful for describing profiles of students' abilities and for vocational guidance counseling.

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[3] Jensen, Harold E., Massey, Iris H., & Valentine, Lonnie D., Jr. Armed Services Vocational Aptitude Battery Development (ASVAB Forms 5, 6, and 7) (Technical Research Note 77-3). Directorate of Testing, U.S. Military Enlistment Processing Command, Fort Sheridan, Ill., December 1977.

Table 6

Intercorrelations and Reliabilities of the New ASVAB-5 Composites

Intercorrelations	V	AQ	CL	M	TT	AA	Average
Differential Abilities							
V	...						
AQ	.72	...					
CL	.38	.49	...				
M	.65	.63	.31	...			
TT	.61	.46	.21	.62	...		.51
General Ability							
AA	.91	.85	.44	.63	.50	...	.67
Reliabilities	.92	.91	.89	.88	.90	.92	.90

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